AMBIENT AIR QUALITY IN THE SARNIA AREA

ANNUAL REPORT 1980

Ministry of the Environment
Ontario

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IN THE
SARNIA AREA

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Technical Support Section
Southwestern Region
ONTARIO MINISTRY OF THE ENVIRONMENT

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SUMMARY

Ambient air quality monitoring in the Sarnia area revealed some marginal improvement in the levels of certain pollutants during 1980 while the levels of other pollutants were similar to levels measured in recent years. Criteria for desirable ambient air quality with respect to sulphur dioxide and suspended particulates are more frequently exceeded at monitoring sites in the City of Sarnia than at sites outside the City where excursions are infrequent. Particulates emitted from construction activity and motor vehicles contribute significantly to the particulate levels measured in Sarnia. The line-up of sources of sulphur dioxide to the south of downtown Sarnia results in several sources being able to impact on Sarnia simultaneously. The 1-hour and 24-hour criteria for sulphur dioxide were again exceeded in downtown Sarnia during 1980. In April, 1981 a control strategy went into effect to prevent excursions of the 24-hour criterion as well as to reduce the frequency of excursions above the 1-hour criterion.

At the two Ministry monitoring stations in the Courtright area there were no excursions recorded above the 1-hour or the 24-hour criterion whereas both criteria were exceeded during 1979. As has been the case in recent years, the annual criterion for sulphur dioxide was not exceeded during 1980 at any Ministry monitoring station in the area.

Throughout Ontario elevated levels of photochemical oxidants in the form of ozone are experienced during the spring and summer. These elevated levels are a result of the long-range transport of ozone and chemicals that react to form ozone, as well as photochemical reactions between local emissions of chemicals. The elevated levels of ozone primarily occur when there are southerly winds associated with weather systems favourable for photochemical

reactions and the long-range transport of pollutants. Adequate control of ozone will be dependent on the development of control strategies at local and international levels. Ozone is being addressed in accordance with the Memorandum of Intent on Transboundary Air Pollution concluded between Canada and the United States on August 5, 1980

Levels of carbon monoxide, nitrogen dioxide, hydrogen sulphide and mercaptans were low during 1980 with no criteria for desirable ambient air quality being exceeded.

Although there were some excursions above criteria for desirable ambient air quality established for fluorides, the criteria are based on the protection of vegetation and no vegetation damage was detected off company property.

INTRODUCTION

The Ontario Ministry of the Environment operates a network of ambient air monitors to measure levels of a number of pollutants that may directly or indirectly adversely affect health, vegetation or the enjoyment of property. Data on levels of pollutants are compared with Ontario's criteria for desirable ambient air quality. Data are also used to determine trends in air quality and therefore the effectiveness of pollution abatement, as well as to provide information on the effect of specific sources of pollutants and to formulate strategies to control pollution.

Ambient air monitoring in the Sarnia area is also conducted by Ontario Hydro, the Lambton Industrial Society and private industry. In addition, the effects of air pollutants on vegetation are determined through phytotoxicology surveys conducted by the Ministry of the Environment.

Emissions from industrial or other sources of pollutants located in Ontario are regulated through a Certificate of Approval. There is an integrated co-operative air pollution control program in the Michigan-Ontario international area between Lake Huron and Lake Erie. Ambient air quality data and reports on emissions and compliance with abatement schedules are exchanged as well as reported to the International Joint Commission.

DESCRIPTION OF MONITORING NETWORK

Continuous and intermittent monitors for determining levels of pollutants in ambient air are maintained by the Ministry at sites dispersed throughout the Sarnia area.

However, monitoring is most intensive in the area of downtown Sarnia because it has a higher potential for elevated levels of pollutants than most other areas in the city. This higher potential is a result of the downtown area being affected by emissions from industries and power plants to the south, as well as by dense vehicular traffic and commercial establishments in the downtown area. The industries and power plants to the south of the downtown area tend to be located along the St. Clair River and plumes from different emission sources may create an additive effect when they impinge on the downtown area. Furthermore, the taller buildings situated in the downtown core will affect wind current and there will be a tendency to bring pollutants from aloft down towards ground level.

During 1980 a van equipped with continuous monitoring instruments was used to measure levels of pollutants in the northern part of Corunna (station 14902) and the extreme southern portion of Sarnia (station 14903). These monitoring sites were selected to obtain data for residential areas adjacent to industry. The locations of the van and other fixed monitoring sites are illustrated in Figure 1. Also included in Figure 1 are the locations of monitoring sites of Ontario Hydro and the Lambton Industrial Society. Specific locations and pollutants monitored are listed in Table 1, Appendix 1.

Criteria for desirable ambient air quality and the supporting rationale for the establishment of these criteria appear in Table 2, Appendix 1.

METEOROLOGICAL DATA

Meteorological data are utilized in predicting the stability of the atmosphere which affects the dispersion of

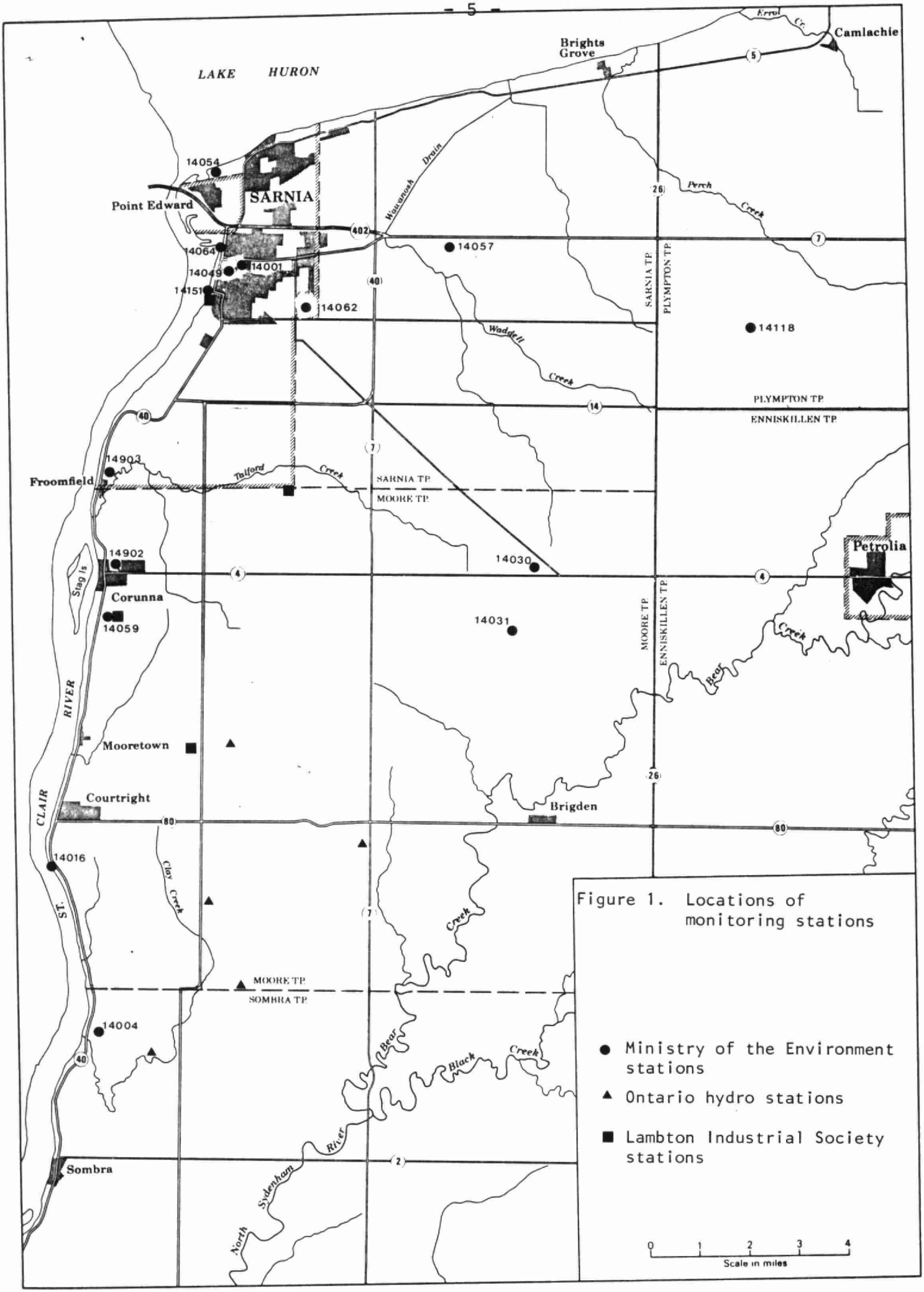


Figure 1. Locations of monitoring stations

- ● Ministry of the Environment stations
- ▲ Ontario hydro stations
- ■ Lambton Industrial Society stations

pollutants. These data also assist in identifying sources of elevated levels of pollutants and in validating mathematical models designed to simulate the dispersion of air pollutants.

The main meteorological tower in the area is located at station 14016 immediately south of Courtright. Wind speed and direction are measured at 10 metres, 30 metres and 92 metres above ground level. In addition, ambient temperature is measured at the 10-metre level and the gradients in temperature between the 10-metre level and the 30- and 92-metre levels are determined. These meteorological data are transmitted by a telemetry system to Toronto where meteorologists utilize them to forecast the stability of the atmosphere. This forecasting feature is an intrinsic part of the Air Pollution Index.

Wind speed and wind direction are also measured at the 10-metre level at station 14062, located in east Sarnia. The monitoring van utilized in the northern part of Corunna and the southern part of Sarnia provided wind speed and wind direction data for the 10-metre level.

Meteorological data from the 30- and 90-metre levels at station 14016 have been used in computing the average concentration of sulphur dioxide for specific wind directions, in order to correlate elevated levels of suspended particulates with wind direction, and to determine the number of hours that the criterion for ozone has been exceeded for different wind directions.

A summary of the frequency of winds for different directions at the 30-metre level at station 14016 appears in Table 3, Appendix 2. The data indicate that the prevailing winds are from the south and southwest.

PARTICULATES

Primary sources of man-caused emissions of particulates to the atmosphere are vehicular traffic, materials handling and combustion processes. Wind-blown particulates from open fields, sand and coal piles, roadways and roofs are also significant sources.

Measurements for particulates are reported as total suspended particulates, dustfall and soiling index. Total suspended particulates are determined by drawing measured volumes of air through a pre-weighed filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter. Dustfall is determined through the exposure of open cylinders (jars) of known diameter for approximately 30 days and subsequently weighing the amount of particulates collected. Soiling index is measured by determining the difference in the amount of light that is transmitted through a filter before and after ambient air is drawn through the filter for 1 hour. The amount of light transmitted through the filter is affected by the quantity, size, shape and opaqueness of particulates retained on the filter. Soiling index can be correlated to levels of suspended particulates and can be determined without the time-consuming laboratory analysis required for determining concentrations of total suspended particulates. For these reasons, soiling index is used as a substitute for suspended particulate values when data are required quickly, such as in the Air Pollution Index.

TOTAL SUSPENDED PARTICULATES

Two criteria for desirable ambient air quality exist for total suspended particulate matter. One is 120 micrograms of suspended particulates per cubic metre of air

(ug/m³) averaged over a 24-hour period. The other is an annual geometric mean of 60 ug/m³. The criterion for 24 hours is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on public awareness of suspended particulates and property damage.

During 1980 total suspended particulates were sampled at 12 sites in the Sarnia area. At 10 of the sites sampling was conducted on an every-sixth-day schedule for the year. At the other 2 sites, sampling was conducted by a monitoring van located in the northern part of Corunna for the first 4 months of 1980 and in the most southern part of Sarnia for the last 8 months of 1980.

At the 6 monitoring sites outside the City of Sarnia and the Village of Point Edward, the annual criterion for desirable ambient air quality was met during 1980. Also, with the exception of 2 values for station 14031, the 24-hour criterion was met at these six sites. The 2 excursions at station 14031 were marginally above the criterion and were probably due to very localized disturbances. It is notable that excursions were not experienced simultaneously at other monitoring sites and meteorological conditions were very different on the two days for which the excursions were reported.

At 5 of the 6 monitoring sites in the City of Sarnia and the Village of Point Edward, the annual geometric means exceeded the annual criterion. The sampling intake of the station (14001) at which the annual criterion was met is at a higher elevation than the intakes for the other stations. The higher sampling intake would be affected to a lesser degree by low level emissions such as road dust and vehicle exhaust. At station 14903, located in the most southerly

area of Sarnia, samples were collected for only 8 months of the year and the computed annual average is not representative of the full year. Also, for station 14903 near-by construction would have contributed to some of the particulate measurements.

While the 24-hour criterion was exceeded at the 6 monitoring sites in Sarnia and Point Edward, the frequencies of excursions above this criterion were quite low (less than 8 percent), with one exception. This exception was station 14064 in Centennial Park, where 12 percent of the results (7 of 56 samples) were above the 24-hour criterion. Elevated results tended to be reported for other monitoring stations for 5 of the 7 days when the 24-hour criterion was exceeded at station 14064. Thus, for 5 of the excursions at 14064 unfavourable meteorology and area sources of particulates are believed to be involved. For the other 2 days, the highest particulate levels for 1980 were measured at station 14064 and were associated with prevailing northwesterly winds. A very localized, unknown source is believed to have been the prime cause of these 2 excursions. A summary of total suspended particulate data for 1980 appears in Table 4, Appendix 3. Figure 2, Appendix 3 shows the annual geometric means and the frequency of excursions above the 24-hour criterion for 1980 at the approximate locations of the monitoring stations.

In general, levels of total suspended particulates in the Sarnia area compare favourably with levels reported for other areas of Ontario. Figure 3, Appendix 3, indicates that for 5 monitoring sites in operation since 1972 the average of the annual geometric means decreased steadily from 1972 to 1975. Since 1975 this average has remained relatively constant. However, Figure 3 does show that the average frequency of excursions above the 24-hour criterion was less for 1980 than for any previous year.

Correlations were determined between levels of suspended particulates determined for samples collected from 10 sites operated throughout 1980 and data for wind speed and direction from the 30-metre level of station 14016,

south of Courtright. The correlations are shown in Figure 4, Appendix 3, with the length of the line corresponding to the various wind directions indicating the strength of the positive correlations. For each monitoring site a positive correlation was determined for southerly, south-southwesterly, and southwesterly winds. This may be attributable to many point and area sources of particulates being south to southwest of Sarnia. Also, southerly winds, which are associated with the backs of high pressure systems and the areas south of low pressure fronts, promote long range transport of pollutants. At some sites positive correlations were produced for northerly winds. Some of these correlations may be a result of several days of elevated levels of suspended particulates associated with a localized source such as previously mentioned for station 14064.

Chemical Analysis of Suspended Particulates

As part of a Province-wide study, samples of suspended particulates collected at 5 stations in the Sarnia area were analyzed for cadmium, chromium, copper, iron, lead, manganese, nickel, and vanadium. Samples from 3 of the 5 sites were also analyzed for nitrates and sulphates as was the case for a sixth site. At the sixth site and a seventh site suspended particulate samples were analyzed for lead. A summary of the data for 1976 through 1980 is contained in Table 5, Appendix 3.

Criteria for desirable ambient air quality exist for cadmium, lead, nickel and vanadium. There have been no values above the criteria and in general the concentrations of the various metals have been low. There is no apparent trend of increasing levels of metals in suspended particulate matter. Average levels of nitrates and sulphates are greater than they were five years ago and a general upward trend is marginally apparent (not statistically significant).

DUSTFALL

The Ministry of the Environment's criteria for desirable ambient air quality with respect to dustfall are 7.0 grams of particulates per square metre per 30 days ($g/m^2/30$ days) in any single month and an annual average of 4.6 $g/m^2/30$ days. These criteria are based on historical data and criteria established by other enforcement agencies.

During 1980 dustfall was sampled at stations 14049 and 14151, located in the downtown core of Sarnia. Except for two monthly samples collected in November and December at station 14049, the samples collected at both stations met the single-month criterion. The elevated results for station 14049 during November and December reflect demolition activity associated with redevelopment in the core area. The annual criterion was exceeded at station 14049 in 1980 but not at station 14151. At the end of 1980 monitoring for all parameters was terminated at station 14049 and shortly thereafter the station was demolished. Levels of dustfall were appreciably lower at station 14151 compared to those at station 14049 which is a reflection of station 14151 being located farther from the demolition activities. In general, dustfall levels measured in the downtown core of Sarnia compare favourable with levels measured in other communities. Table 6, Appendix 3 contains the data for 1972 through 1980.

SULPHUR OXIDES

Combustion of sulphur-containing fuels comprises the predominant source of man-made emissions of sulphur oxides. In the Sarnia area large quantities of these fuels are consumed by power-generating plants in Michigan and Ontario and by petroleum and petrochemical industries located south of downtown Sarnia.

Sulphur oxides are monitored in the Sarnia area by this Ministry as gaseous sulphur dioxide using continuous monitors and as sulphate in suspended particulate matter, as described in the previous section of this report.

SULPHUR DIOXIDE

Throughout 1980 the Ministry maintained gaseous sulphur dioxide monitors at 5 separate sites in the Sarnia area. At an additional site in Corunna sulphur dioxide was monitored for 4 months. An attempt was made to monitor sulphur dioxide in the most southern part of Sarnia but instrumentation problems resulted in the data being unreliable. There were 11 other sites where monitors providing continuous measurements of sulphur dioxide were operated by Ontario Hydro, the Lambton Industrial Society or private industry. Data from these 11 sites are not included in this report.

Data are reported as 1-hour average concentrations, 24-hour average concentrations (midnight to midnight) and annual average concentrations. Criteria for desirable ambient air quality are 0.25 parts of sulphur dioxide per million parts of air (ppm) averaged for a 1-hour period, 0.10 ppm averaged for 24 hours and 0.02 ppm as an annual average. The criteria for the 1-hour and annual averages are based on the protection of vegetation while the 24-hour criterion is based on the protection of human health.

During 1980 the annual criterion was not exceeded. Neither the 1-hour nor the 24-hour criterion was exceeded at the two Ministry monitoring stations south of Courtright nor were these criteria exceeded during the 4 months that monitoring was conducted in north Corunna. Since monitoring for sulphur dioxide began south of Courtright in 1973, 1980 was the

first year when no excursions above either the 1-hour or 24-hour criterion were measured. Data from monitors operated by the Lambton Industrial Society and Ontario Hydro revealed some infrequent excursions above the 1-hour criterion in the area south of Courtright and Corunna during 1980.

At the 3 sites in Sarnia at which the Ministry measures gaseous sulphur dioxide (stations 14049, 14062 and 14064) the 1-hour criterion was exceeded. The 24-hour criterion was exceeded at stations 14049 and 14064. Monitoring of sulphur dioxide at station 14062, located in east Sarnia, began in late 1977 and the first excursions measured above the 1-hour criterion were the 3 detected in 1980. The frequencies of excursions detected at stations 14049 and 14064 were similar to those of recent years. A new regulation, which became effective in 1981, requires some sources of sulphur dioxide in Lambton County to provide additional controls such that the frequency of excursions should be appreciably reduced. A summary of sulphur dioxide data for 1980 appears in Table 7, Appendix 4. For those stations operating at least 5 years, an illustration of the trend in the frequencies of excursions above the 1-hour and 24-hour criteria is presented in Figure 5, Appendix 4.

Pollution roses were created using data for wind direction and speed from the 90-metre level of station 14016 and concentrations for sulphur dioxide determined at the various stations. The pollution roses appear in Figure 6, Appendix 4. The length of the line corresponding to a specific wind direction indicates the average sulphur dioxide concentration determined at the particular station when winds were from that direction. The roses for stations 14049, 14062 and 14064 in Sarnia and station 14902 in Corunna reveal higher levels of sulphur dioxide when winds are blowing from the industries located in south Sarnia and immediately south of Sarnia. Two of the largest sources of

sulphur dioxide in the Sarnia area are the Lambton Generating Station of Ontario Hydro and the St. Clair Power Plant of Detroit Edison. These two sources, which are located south of Courtright, would contribute to the sulphur dioxide concentrations associated with southerly and south-south-westerly winds recorded at the monitoring stations in Corunna and Sarnia.

AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forecasting and current readings of sulphur dioxide and suspended particulates are utilized to predict the potential for persistence of pollution conditions that are reported as the API.

Data for suspended particulates are provided by the measurement of soiling index and a correlation between concentrations of suspended particulates and soiling index. The correlation between concentrations of suspended particulates and soiling index was updated at the beginning of 1980 resulting in a modification to the API equation. The new API equation is:

$$API = 3.02\ (9.75\ COH + 125.95\ SO_2)^{0.76}$$

where: COH is the 24-hour running average soiling index expressed in units of coefficient of haze. SO_2 is the 24-hour running average of sulphur dioxide expressed in parts per million.

API values below 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if ad-

verse weather conditions are likely to persist, those responsible for major emissions are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. If the API reaches 100 all industries and other contributors of pollution not essential to public health and safety may be ordered to cease operation.

Although the API is based on the control of combined levels of sulphur dioxide and suspended particulates, emissions of other pollutants may be controlled simultaneously. However, situations may occur where levels of certain pollutants such as ozone may be high and the API may be quite low. The normal monitoring program of the Ministry is used to detect elevated levels of other pollutants.

Sulphur dioxide and soiling index data utilized to determine the API for Sarnia are obtained from monitors operated at station 14064 in the downtown core. During 1980 the API reached the Advisory Level for 15 hours with the maximum level being 39. The 15 hours when the API was at the Advisory Level were during March 20, 1980 and were associated with an extended period of southerly winds. With the exception of these 15 hours, the API for Sarnia was in the acceptable range during 1980.

The new control strategy implemented for sulphur dioxide in 1981 will tend to result in cut-backs in sulphur dioxide emissions prior to the API reaching the Advisory Level.

HYDROGEN SULPHIDE AND MERCAPTANS

Mercaptans are a group of organic compounds that contain sulphur and hydrogen and exhibit characteristics

similar to hydrogen sulphide. Hydrogen sulphide is commonly referred to as rotten egg gas and many mercaptans are also malodorous at extremely low concentrations.

Both hydrogen sulphide and mercaptans originate in nature from anaerobic decomposition of organic matter containing sulphur. In the Sarnia area, the release of hydrogen sulphide and mercaptans into the atmosphere may result from the processing of petroleum feedstocks containing sulphur.

The criterion established to represent desirable ambient air quality with respect to hydrogen sulphide is 0.02 ppm as an average for 1 hour. This criterion is based on the offensive odours exhibited by this gas. Similarly, the criterion for mercaptans is based on odour and was established as 0.01 ppm averaged for 1 hour and expressed as methyl mercaptan.

Unfortunately, the monitoring instrument in Sarnia does not segregate hydrogen sulphide from mercaptans but determines their combined concentrations and reports these concentrations in terms of hydrogen sulphide. To adjust for this situation the combined concentrations of hydrogen sulphide and mercaptans are compared to the less restrictive criterion for hydrogen sulphide.

During 1980 the hourly criterion of 0.02 ppm was not exceeded at station 14062 located in east Sarnia. A summary of data is presented in Table 8, Appendix 5, for levels of hydrogen sulphide and mercaptans measured in downtown Sarnia at station 14049 from 1974 to 1978 and at station 14062 from October 1978 through 1980. The lower levels of hydrogen sulphide and mercaptans in recent years reflect the improvements in control of emissions.

CARBON MONOXIDE

Combustion processes represent man's major emissions of carbon monoxide. Emissions from motor vehicles are most significant because they occur near ground level and are concentrated in urban areas where the public may be exposed for lengthy periods. Industries and power-generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in the ambient air.

The criteria for carbon monoxide, which are based on the protection of human health, are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8-hour period.

During 1980 carbon monoxide was monitored at station 14064, located in the downtown core at Centennial Park. The criteria for desirable ambient air quality were not exceeded. Prior to July 1978, carbon monoxide was measured in downtown Sarnia at station 14049. A summary of data for carbon monoxide obtained since 1974 is presented in Table 8, Appendix 5, and illustrates long-term conformity below established criteria.

OXIDES OF NITROGEN

Oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are the compounds of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria, which are based on offensive odours and the protection of human health, are 0.20 ppm

averaged for 1 hour and 0.10 ppm averaged for 24 hours. These criteria were not exceeded during 1980 at station 14064, located in the downtown core area. Nor were the criteria exceeded at stations 14902 and 14903, located in Corunna, and the extreme south part of Sarnia, respectively. Monitoring for oxides of nitrogen was conducted at these latter two stations for 4 months and 5 months, respectively.

A summary of data for oxides of nitrogen, presented in Table 8, Appendix 5, illustrates that levels of nitrogen dioxide are consistently below the established criteria. Levels of nitric oxide and total nitrogen oxides are in ranges typical for communities the size of Sarnia.

Oxides of nitrogen in combination with reactive hydrocarbons under certain meteorological conditions play an important role in the formation of unsatisfactory levels of photochemical oxidants. Also, oxides of nitrogen react to form acids which are part of acidic precipitation. Therefore, consideration is being given to further controls on emissions of oxides of nitrogen.

HYDROCARBONS

Emissions from motor vehicles are a primary man-made source of hydrocarbons in the ambient air. Other significant man-made sources are incomplete combustion of fuels by industries and power plants, and evaporation losses during the storage and transportation of hydrocarbons. Natural phenomena also produce many hydrocarbons of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable ambient air quality have been established for

total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Values for total hydrocarbons determined during 1980 at station 14064 in the downtown core of Sarnia, at station 14902 in Corunna and at station 14903 in the extreme south of Sarnia were comparable to levels measured in other communities. At station 14902 and 14903 monitoring was conducted for 111 and 217 days, respectively, and data are reported as total hydrocarbons, methane and non-methane hydrocarbons. Periodically elevated levels of non-methane hydrocarbons were detected at station 14903. These elevated levels were generally associated with very light to calm wind conditions, which made identification of the source difficult. However, there was a tendency for winds to be from the south-west quadrant during the incidences of elevated non-methane hydrocarbons. On one occasion, a bag of ambient air was collected at the station simultaneously to elevated levels of non-methane hydrocarbons. Although this one sample, which was analyzed for a variety of hydrocarbons, did not provide sufficient information to identify the source, the analytical results tended to rule out motor vehicle exhaust as the primary source. Further investigation into the source and the nature of the non-methane hydrocarbons is planned for 1981.

A summary of data for hydrocarbons appears in Table 8, Appendix 5.

OXIDANTS

Oxidants in the ambient air are primarily a result of a series of photochemical reactions and inter-reactions

involving oxides of nitrogen and non-methane hydrocarbons. The reactions are promoted by certain meteorological conditions such as warm temperatures and intensive sunshine, resulting in higher levels of oxidants in the spring and summer months.

Throughout 1980 the Ministry of the Environment measured oxidants in the form of ozone at station 14064 in the downtown core of Sarnia, and station 14118, situated in a rural setting approximately 10 kilometres east of Sarnia. Ozone was also monitored from January 1 to May 1, 1980 at station 14902 located in Corunna and at station 14903 in the extreme south of Sarnia from May 15, 1980 to December 31, 1980. Ozone normally accounts for 80 to 95 percent of the oxidants present in ambient air. Consequently, with technology for monitoring ozone being more accurate and efficient than for total oxidants, most regulatory agencies monitor for ozone.

Long-range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) may account for a very significant portion of local levels of ozone. Long-range transport from distances greater than 200 kilometres has been reported in the literature. Therefore, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario.

Ozone is also present in the stratosphere where it plays a critical role in absorbing excessive amounts of ultraviolet solar radiation that may be biologically harmful. Occasionally, ozone from the stratosphere may be transported downwards to create elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

The criterion for desirable ambient air quality established for ozone is 80 parts per billion (ppb) averaged

for 1 hour. This criterion was established for the protection of vegetation, property and human health. Some effects that are detrimental to health and are associated with oxidants are eye irritation and a decrease in performance during athletic endeavors.

During 1980 the criterion was exceeded 68 times at station 14064 in the downtown core and 39 times at station 14118 in the rural area east of Sarnia. Also, during the 4 months of monitoring at station 14902 in Corunna, the criterion was exceeded once, and it was exceeded 81 times during the 7½ months of monitoring at station 14903 in south Sarnia. Monitoring at station 14902 occurred when meteorological conditions were unfavourable for photochemical reactions and hence only the one excursion was measured. Prior to July, 1978, ozone monitoring in the downtown core was conducted at station 14049 rather than station 14064. Station 14049 experienced higher levels of pollutants (other than ozone) than station 14064, whereas one might have anticipated lower frequencies of excursions for ozone at the former station because of greater scavenging of ozone by the other pollutants. A summary of ozone data is presented in Table 9, Appendix 5. Since the formation of oxidants is heavily dependent on meteorological conditions, fluctuations in the frequencies of excursions from year to year are to be expected.

Pollution roses for 1980 for ozone, which appear in Figure 7, Appendix 5, illustrate the percentage of the total number of excursions at stations 14064 and 14118 that are associated with different wind directions. It is evident from the roses that the majority of excursions are associated with southerly and south-southwesterly winds. Southerly and south-southwesterly winds are apt to be associated with the backs of high pressure systems or the area south of low pressure fronts which have weather favourable for photochemical reactions (clear sunny skies and warmer temper-

atures) and which promote long-range transport of oxidants and their precursor chemicals from the United States.

As a result of the United States-Canada Memorandum of Intent on Transboundary Air Pollution, signed August 5, 1980, working groups represented by experts from both countries are addressing the significance of long-range transport of ozone and its precursor chemicals.

FLUORIDES

In the Sarnia area fluoride is emitted into the atmosphere from fossil-fueled power plants where it exists as an impurity in coal, from a fertilizer plant where it occurs as a constituent of phosphate rock, and from petroleum refineries where it is used as a catalyst in alkylation.

Fluoridation rate is a measurement designed to indicate relative amounts of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and subsequently analyzed for fluoride content. This technique is inexpensive compared to other methods for measuring airborne fluorides. Some fluorides in particulate form are collected on the filters.

Criteria for desirable ambient air quality established for fluoridation rate are based on protection of vegetation. A criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ugF/100 cm^2/30 days) exists for the growing season of April 15 to October 15 and a less stringent criterion of 80 ugF/100 cm^2/30 days exists for the period of October 16 to April 14. Since the months of April and October are common to both criteria and fluoridation rate is determined on a monthly basis, excursions above the criteria during these months are determined by comparing fluoridation rate to the average of the two criteria (60 ugF/100 cm^2/30 days).

The Ministry monitors fluoridation rate at station 14004, located south of Courtright in the vicinity of the fertilizer complex of Canadian Industries Limited and power plants of Ontario Hydro and Detroit Edison, and at station 14049 in downtown Sarnia. Canadian Industries Limited has maintained a detailed network of fluoridation candles for many years and also operates a continuous gaseous fluoride analyzer.

During 1980 the criterion for the growing season was exceeded at station 14004 for the 4 consecutive months of May through August and the fluoridation rate for April exceeded the average of the two criteria. The less stringent criterion for the non-growing season was not exceeded. Frequent excursions of the growing season criterion have been occurring since monitoring began at station 14004 in 1978. At station 14049 the criterion for the growing season was exceeded for 1 month during 1980 as was the criterion for the non-growing season. Table 10, Appendix 6 presents data for fluoridation rate from 1972 to 1980.

Fluoridation rate serves to indicate if levels of fluorides exist that might cause vegetation damage. Annual phytotoxicology surveys have not revealed vegetation damage attributable to fluorides in Sarnia or outside of company property in the Courtright area.

Table 1. Locations of monitoring stations and parameters being monitored.

Station No.	Location	Parameters measured	Height of measurements	Purpose of stations and comments
14001	Sarnia General Hospital	Suspended particulates	16 m.	Historical station which has been in operation since 1962. Does not reflect ground level concentrations but does indicate more direct effects of particulates from high stacks and long-range transport.
14004	5½ miles south of Courtright	Continuous SO_2 fluoridation rate	4 m.	Monitors SO_2 from power generating stations and fluorides from fertilizer industry.
14016	1¼ miles south of Courtright	Suspended particulates continuous SO_2, WS, WD, Temp., WS, WD, Temp., WS, WD, Temp., telemetering equipment	1 m. 10 m. 30 m. 92 m.	Monitors suspended particulates and sulphur dioxide in relation to power generating plants. Provides meteorological data required for stability forecasts and air quality interpretations.
14030	R. R. #1 Corunna	Suspended particulates	3 m.	Monitors particulates in the vicinity of of Tricil Limited.
14031	R. R. #1 Mooretown	Suspended particulates	3 m.	Monitors particulates in the vicinity of Tricil Limited.
14049	Victoria Street	Continuous SO_2, suspended particulates, dustfall, fluoridation rate	4 m.	Monitors air pollutants in a heavily populated area where the pollutants from traffic, commercial establishments and the heavily industrialized complex south of the monitoring station should be high relative to residential areas.

Table 1. continued

Station No.	Location	Parameters measured	Height of measurements	Purpose of stations and comments
14054	Sarnia Yacht Club	Suspended particulates	5 m.	Monitors suspended particulates in the north Sarnia-Point Edward area.
14057	Briarwood Recreation Centre	Suspended particulates	10 m.	Monitors suspended particulates in Sarnia Township, northeast of the main industrial area.
14059	Riverbend, Corunna	Suspended particulates	4 m.	Monitors suspended particulates in the residential area of Corunna which is surrounded by industry and generating stations.
14062	Eastland Plaza, 242A Indian Rd. S.,	Continuous SO_2, H_2S & mercaptans WS, WD	6 m. 10 m.	Monitors SO_2, H_2S and mercaptans in residential-commercial area of east Sarnia which is adjacent to refinery operations. Provides meteorological data useful in identifying sources of pollutants.
14064	Centennial Park Front Street, Sarnia	Continuous SO_2, CO, NO, NO_2, NO_x, O_3, total hydrocarbons, 1-hr COH, suspended particulates, telemetering equipment	3 m.	Monitors main air pollutants in an area adjacent to downtown Sarnia and in line with many point sources of pollution located to the south of the downtown area. Provides Air Pollution Index for Sarnia.
14118	Petrolia Public Utilities Commission Pumping Station, 4 miles west of Wyoming.	O_3	5 m.	Monitors ozone levels in a rural location

Table 1. continued

Station No.	Location	Parameters measured	Height of measurements	Purpose of stations and comments
14151	Front and David Streets, downtown Sarnia	Suspended particulates dustfall	3 m.	Monitors pollutants in commercial area which is also affected by heavily industrialized area to south. Since this is the location of a monitoring station operated by the Lambton Industrial Society, cross checking of monitoring techniques is possible.
14902	Paget St., Corunna	Continuous SO_2, NO, NO_2, NO_x, O_3, methane, total & non-methane hydrocarbons, suspended particulates,	3 m.	Main air pollutants monitored in residential area of north Corunna using instrumented van for several months.
		wind speed and direction	10 m.	
14903	Virgil St., Sarnia	Continuous SO_2, NO, NO_2, NOx, O_3, Methane, total & non-methane hydrocarbons, suspended particulates,	3 m.	Main air pollutants in small residential area of southern Sarnia using instrumented van for eight months.
		wind-speed and direction.	10 m.	

Table 2. Desirable ambient air quality criteria established for Ontario

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour	Protection of human health
	13 ppm averaged for 8 hours	Protection of human health
Dustfall	7.0 g/metre² in 30 days	Historical and in keeping with other control agencies
	4.6 g/metre² (mean monthly average in 1 year)	
Fluoridation rate	40 ug F/100 cm² of limed filter paper in 30 days during April 15 to October 15.	Protection of vegetation
	80 ug F/100 cm² of limed filter paper in 30 days during October 16 to April 14.	Protection of vegetation (less restrictive criterion during the non growing season)
Hydrocarbons (total, methane & non-methane)	NONE	Effects of hydrocarbons vary widely depending on their chemical-physical nature. Certain non-methane hydrocarbons may react photochemically to produce oxidants.
Hydrogen sulphide	0.02 ppm averaged for 1 hour	Protection against offensive odours.
Mercaptans	0.01 ppm averaged for 1 hour	Protection against offensive odours.
Nitric oxide	NONE	Reacts with oxygen to produce NO_2.
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against offensive odours.
	0.10 ppm averaged for 24 hours	Protection of human health and protection against offensive odours.

Table 2. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Oxides of nitrogen	NONE	
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation, adverse health effects
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged for 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m³ averaged for 24 hours	Based on health effects in conjunction with elevated levels of SO_2 and impairment of visibility.
	A geometric mean of 60 ug/m³ during 1 year	Based on public awareness of visible pollution
Cadmium in suspended particulates	2.0 ug/m³ averaged for 24 hours	Protection of human health
Lead in suspended particulates	5 ug/m³ averaged for 24 hours	Protection of human health
	A geometric mean of 2 ug/m³ over a 30-day period	Protection of human health
Nickel in suspended particulates	2.0 ug/m³ averaged for 24 hours	Protection of vegetation
Vanadium in suspended particulates	2.0 ug/m³ averaged for 24 hours	Protection of human health

APPENDIX 2

METEOROLOGICAL DATA

Table 3. Percent frequencies of wind directions at the 30-metre level of station 14016.

Year	N	NE	E	SE	S	SW	W	NW
1980	12.6	8.6	5.6	7.5	20.1	15.1	14.4	16.1
1979	10.7	8.7	6.5	8.9	24.7	14.7	11.9	14.0
1978	13.6	12.7	6.3	6.0	19.0	17.2	11.9	13.3
1977	11.3	9.8	5.3	7.2	18.5	21.2	14.1	12.6
1976	12.2	9.2	3.5	4.7	18.1	20.5	15.1	16.7
1975	9.4	11.6	6.7	7.6	19.3	20.5	12.9	12.1
1974	12.2	10.6	5.2	5.7	20.6	21.6	12.1	12.1
1973	11.6	11.0	8.1	7.2	15.8	20.6	12.9	12.8
1972	15.8	12.0	6.5	8.3	17.4	16.4	11.7	12.0

APPENDIX 3

PARTICULATES

Table 4. Summary of 1980 data for total suspended particulates.

Station No.	No. of samples collected	Annual geometric mean (ug/m³)	No. of values greater than 24-hour criterion	Percentage of values greater than 24-hour criterion
14001	53	58	1	2
14016	57	48	0	0
14030	51	43	0	0
14031	54	44	2	4
14049	59	68	2	3
14054	57	63	4	7
14057	54	49	0	0
14059	59	46	0	0
14064	57	76	7	12
14151	59	62	3	5
14902	18	(42)	0	0
14903	36	(65)	1	3

Note: Bracketed annual geometric means are not representative of sampling for complete year.

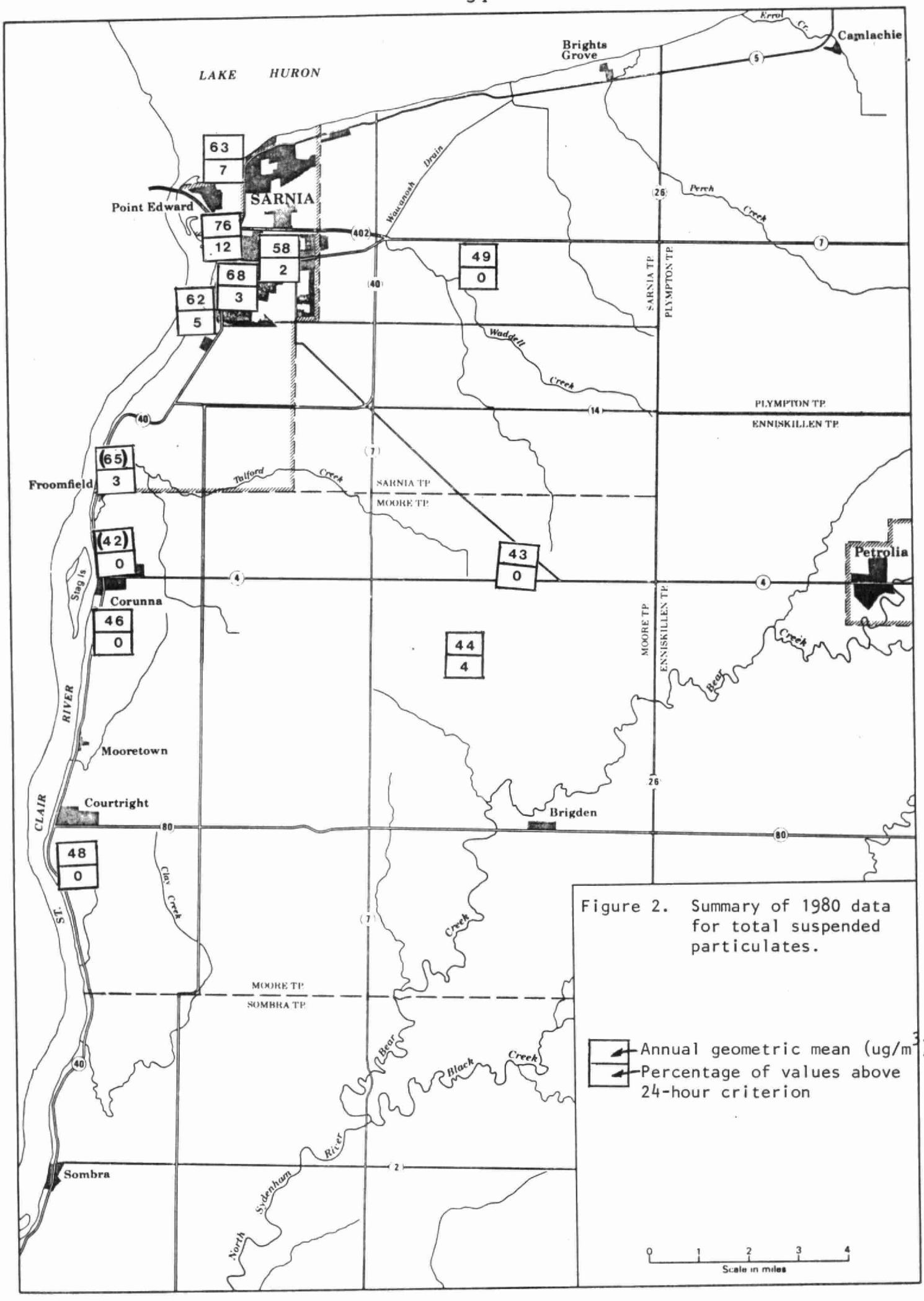
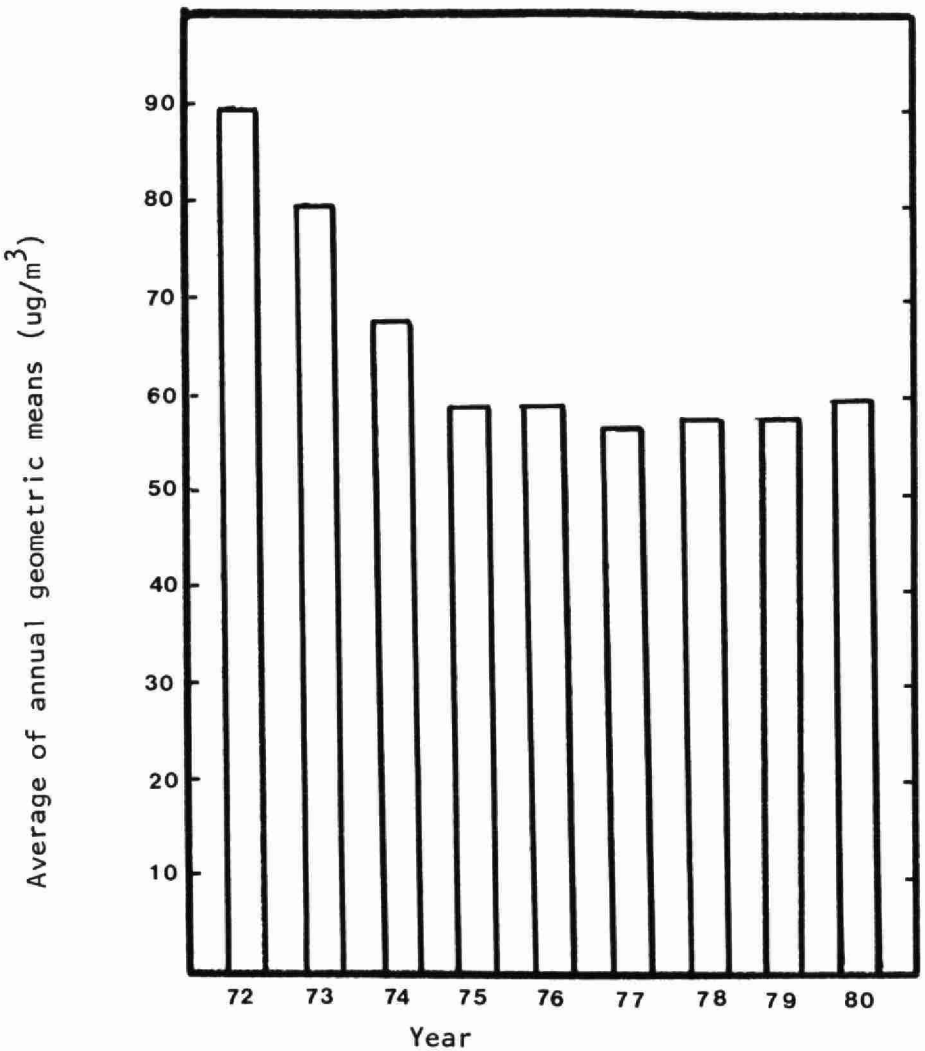
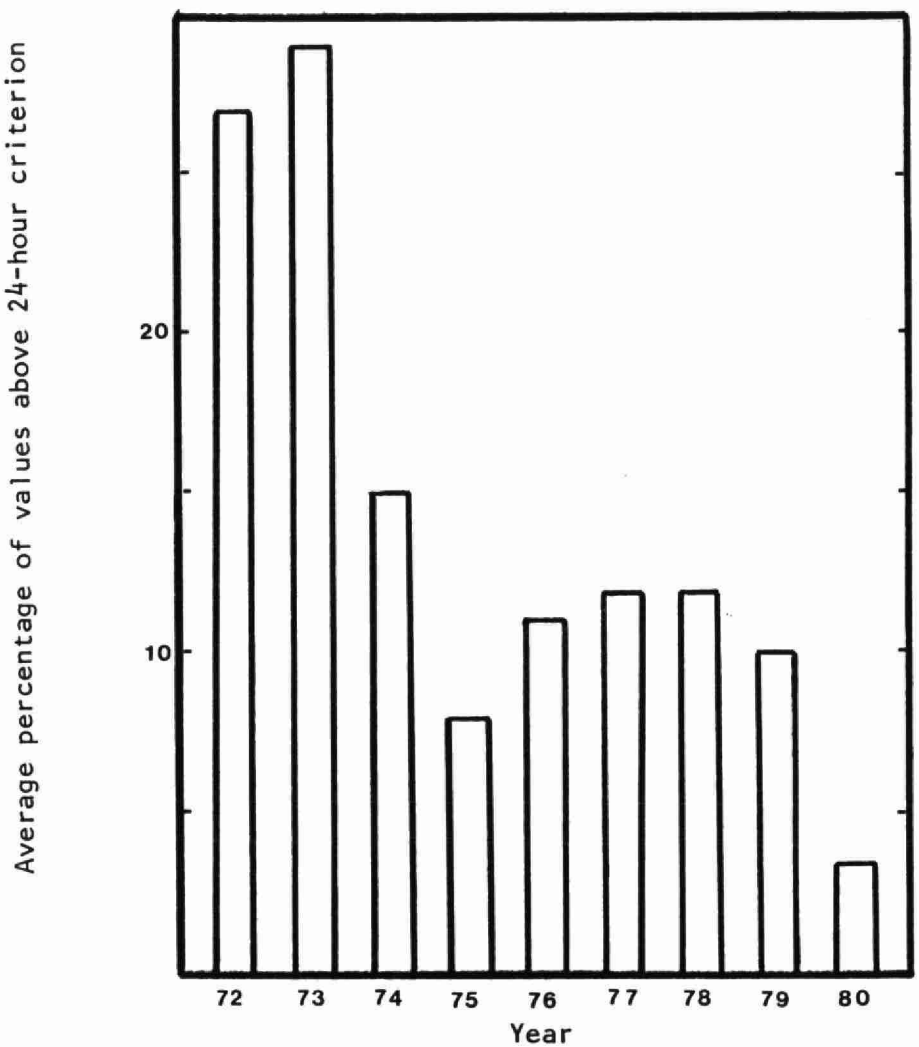


Figure 2. Summary of 1980 data for total suspended particulates.

Figure 3. Trend in levels of total suspended particulates based on data averaged for five monitoring stations from 1972 to 1980.





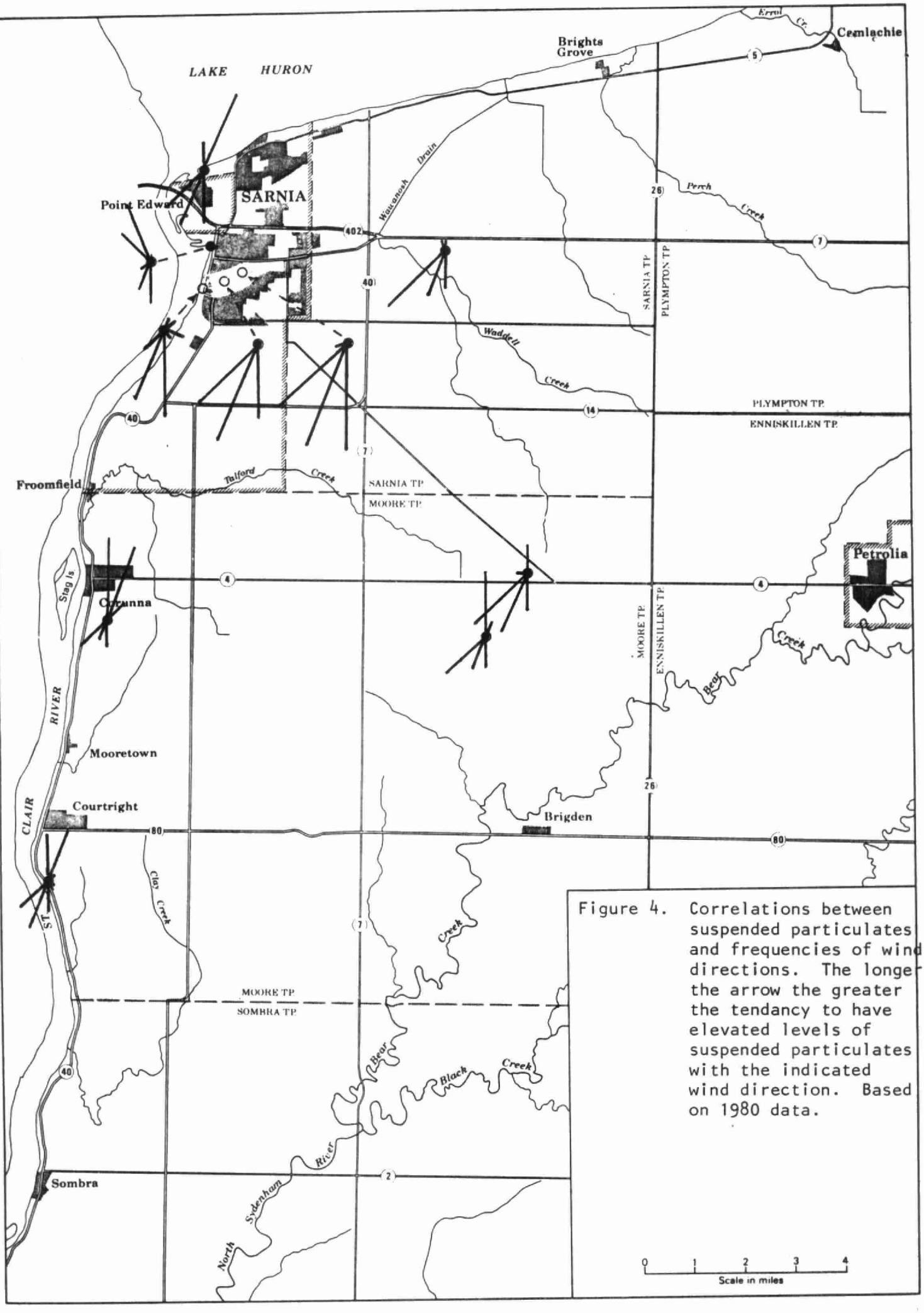


Figure 4. Correlations between suspended particulates and frequencies of wind directions. The longer the arrow the greater the tendancy to have elevated levels of suspended particulates with the indicated wind direction. Based on 1980 data.

Table 5. Concentrations (ug/m³) of various constituents of suspended particulates: 1976 to 1980.

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
14001															
1976	10	0.001	0.004	10	0.017	0.066	10	0.31	0.73	10	1.0	2.4	10	0.3	0.6
1977	18	0.000	0.003	18	0.009	0.030	18	0.68	2.48	18	1.2	5.8	18	0.3	1.3
1978	24	0.001	0.005	24	0.010	0.023	24	0.22	0.54	24	1.1	4.0	24	0.2	0.7
1979	32	0.001	0.003	32	0.003	0.013	32	0.23	0.62	32	0.8	3.0	32	0.2	0.4
1980	24	0.001	0.004	24	0.001	0.007	24	0.19	0.56	24	0.9	2.3	24	0.3	0.5
14016															
1976	18	0.000	0.003	18	0.003	0.011	18	0.41	1.17	18	0.6	1.6	18	0.2	0.4
1977	21	0.000	0.002	21	0.008	0.025	21	0.31	0.58	21	0.6	1.8	21	0.2	0.6
1978	26	0.001	0.003	26	0.007	0.019	26	0.50	1.38	26	0.9	3.2	26	0.1	0.4
1979	35	0.001	0.004	35	0.002	0.010	35	0.39	1.01	35	0.8	2.9	35	0.2	0.6
1980	25	0.001	0.004	25	0.002	0.009	25	0.44	0.96	25	0.6	1.8	25	0.1	0.4
14030															
1978	11	0.002	0.004	11	0.007	0.019	11	0.37	0.98	11	1.2	2.2	11	0.3	0.9
1979	50	0.001	0.004	50	0.007	0.022	50	0.32	1.36	55	0.6	2.2	54	0.1	0.4
1980	52	0.001	0.004	52	0.003	0.023	52	0.47	2.34	52	0.5	1.5	52	0.1	0.3
14031															
1978	12	0.002	0.003	12	0.004	0.008	12	0.44	1.00	12	0.7	1.3	12	0.1	0.3
1979	54	0.001	0.005	54	0.010	0.189	54	0.25	0.97	58	0.5	2.7	54	0.1	0.4
1980	54	0.001	0.004	54	0.005	0.030	54	0.13	0.26	54	0.5	2.2	54	0.1	0.3
14051 (14151)															
1976	17	0.001	0.003	18	0.032	0.157	17	0.08	0.15	17	1.0	3.4	17	0.3	0.8
1977	20	0.000	0.003	20	0.007	0.021	20	0.10	0.28	20	0.6	1.3	20	0.2	0.5
1978	21	0.001	0.005	21	0.006	0.016	21	0.09	0.40	21	1.0	3.1	21	0.3	0.9
1979	30	0.001	0.007	30	0.004	0.016	30	0.05	0.27	30	1.5	4.9	30	0.3	0.7
1980	21	0.002	0.004	21	0.007	0.012	21	0.07	0.18	21	1.4	2.6	21	0.3	0.6

Table 5. continued

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
14049															
1976													70	0.5	1.5
1977													50	0.6	1.3
1978													50	0.5	1.7
1979													56	0.3	1.3
1980													55	0.3	0.7
14054															
1976													3	0.2	0.3
1977													15	0.2	0.5
1978													57	0.2	1.3
1979													55	0.2	1.1
1980													53	0.2	1.0

Table 5. continued

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
14001															
1976	2	0.30	0.37	10	0.029	0.107	58	3.8	15.8	58	8.6	44.6	10	0.02	0.11
1977	18	0.04	0.23	18	0.014	0.064	47	4.7	24.5	48	12.9	43.9	18	0.01	0.07
1978	24	0.08	0.58	24	0.010	0.033	52	4.6	21.3	51	11.1	39.7	24	0.00	0.02
1979	32	0.06	0.38	32	0.010	0.076	54	4.8	16.0	54	11.0	35.7	32	0.01	0.07
1980	24	0.03	0.13	24	0.010	0.033	55	5.5	18.4	55	13.4	28.6	24	0.01	0.04
14016															
1976	8	0.01	0.04	18	0.013	0.031	96	4.0	20.0	105	8.7	33.4	18	0.00	0.02
1977	21	0.03	0.09	21	0.022	0.165	54	3.7	27.8	54	10.0	24.6	21	0.01	0.08
1978	26	0.02	0.06	26	0.016	0.194	53	4.6	24.6	53	11.2	35.3	26	0.00	0.10
1979	35	0.02	0.07	35	0.008	0.042	56	5.4	14.8	56	12.4	41.0	35	0.00	0.01
1980	25	0.02	0.10	25	0.010	0.064	56	4.8	11.4	56	11.5	25.1	25	0.01	0.10
14030															
1978				11	0.009	0.013									
1979	45	0.01	0.05	50	0.006	0.032							45	0.00	0.02
1980	50	0.01	0.08	52	0.004	0.026							50	0.00	0.01
14031															
1978				12	0.016	0.057									
1979	46	0.02	0.07	54	0.009	0.171							46	0.00	0.01
1980	52	0.02	0.11	54	0.005	0.021							47	0.01	0.02
14051 (14151)															
1976	17	0.03	0.07	17	0.023	0.084	59	3.7	11.7	58	9.3	45.1	17	0.03	0.12
1977	20	0.03	0.06	20	0.009	0.022	56	3.9	22.4	56	10.9	32.1	20	0.00	0.02
1978	21	0.06	0.18	21	0.012	0.047	59	5.4	19.2	59	12.8	47.1	21	0.01	0.12
1979	30	0.06	0.33	30	0.018	0.077	44	6.1	25.4	44	13.5	42.2	30	0.02	0.10
1980	21	0.05	0.15	21	0.015	0.076	59	4.9	16.2	59	12.3	26.5	21	0.02	0.07

Table 5. continued

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
14054															
1976							54	3.7	13.2	61	8.9	34.8			
1977							49	3.8	20.2	49	10.1	25.7			
1978							49	4.8	20.4	49	11.5	37.0			
1979							55	5.1	14.3	55	12.5	39.2			
1980							57	5.2	14.8	57	12.4	27.6			

Table 6. Values for dustfall (g/m²/30 days) in downtown Sarnia

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Arithmetic Mean
Station 14049													
1972		7.4	7.7	7.0	2.1		2.5	3.2	2.1	4.2		3.2	4.4
1973	5.3	3.5	10.5	4.6	7.7	4.6	3.9	2.8	3.5	6.0	8.8	3.5	5.4
1974	3.5	4.6	9.8	5.6	5.6	6.0	4.2	2.5	3.2	3.5	4.2	3.9	4.7
1975	4.2	4.2	6.0	6.0	6.0	4.6	3.2	6.7	4.2	5.6	3.9	2.8	4.8
1976	2.8	6.0	8.1	6.7	5.6	4.9	4.9	3.2	3.5	4.6	4.3	4.2	4.9
1977	1.6	5.9	8.7	5.4	5.0	5.5	2.6	3.0	4.4	3.3	5.6	5.5	4.7
1978	1.1	2.0	9.1	7.1	3.0	5.5	4.1	2.9	4.5	2.0	3.7	6.4	4.3
1979	2.7	5.1	5.7	13.3	8.3	5.3	4.7	3.4	4.6	3.7	4.9	2.6	5.4
1980	5.4	2.4	6.7	4.0	5.0	6.0	2.5	3.0	3.9	4.1	11.0	9.1	5.3
Station 14051 (14151)													
1972				7.4			2.1	6.7	4.9	3.9		3.2	4.7
1973	3.5	2.5	6.3	5.6	6.3	6.3	1.8	2.5	2.8	4.9	5.6	2.8	4.2
1974	3.2	4.9	7.0	7.0	5.6	7.0	4.9	2.8	4.2	4.6	3.2	4.2	4.9
1975	4.6	2.1	4.2	2.1	5.6	5.2	4.2	9.1	3.5	5.6	4.2	2.1	4.4
1976	3.2	4.9	6.7	5.3	4.9	4.6	3.5	3.2	2.8	3.2	2.8	2.8	4.0
1977	0.9	3.9	5.6	5.5	4.9	5.2	4.6	4.0	5.1	3.1	4.4	4.4	4.3
1978	1.5	0.9	19.7	12.7	6.3	5.4	4.8	4.3	7.2	4.7	4.6	3.7	6.3
1979			4.6	6.2		4.3	4.9	2.0	3.0	3.1	3.5		4.0
1980	2.2	1.9	3.8	4.0	3.5	5.3	2.0	3.5	5.7	3.8	2.1	2.2	3.3

Underlined values exceed either the criterion of 7.0 g/m²/30 days or the annual criterion of an average of 4.6 g/m²/30 days.

Station 14051 was replaced with station 14151 in February 1979.

APPENDIX 4

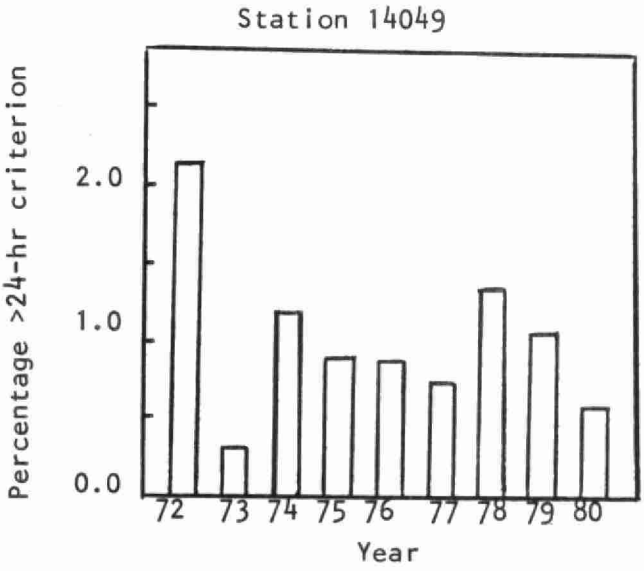
SULPHUR OXIDES

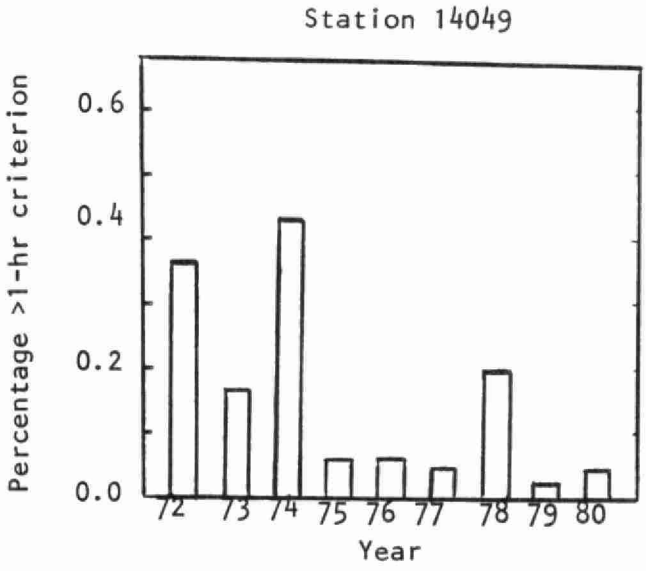
Table 7. Summary of 1980 data for sulphur dioxide

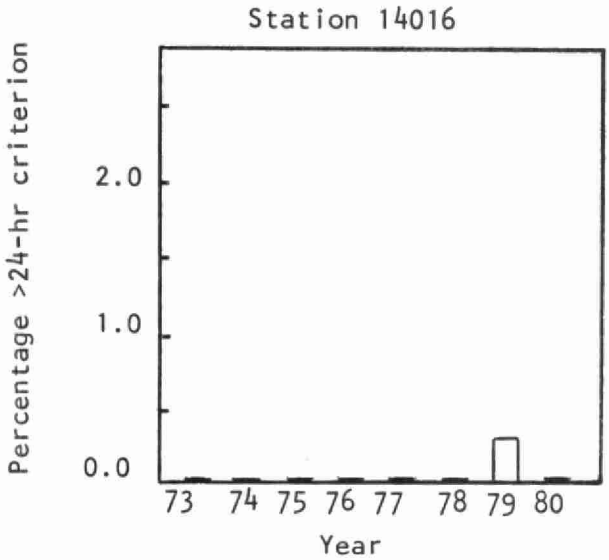
Station No.	Annual average (ppm)	Percentage of values above criterion 1-hour	24-hour	Maximum 1-hour value (ppm)	Maximum 24-hour (daily) value (ppm)
14004	0.00	0	0	0.23	0.04
14016	0.01	0	0	0.25	0.07
14049	0.01	0.05	0.57	0.32	0.12
14062	0.01	0.04	0	0.31	0.07
14064	0.01	0.06	0.28	0.35	0.12
14902	0.02(1)	0	0	0.25	0.07

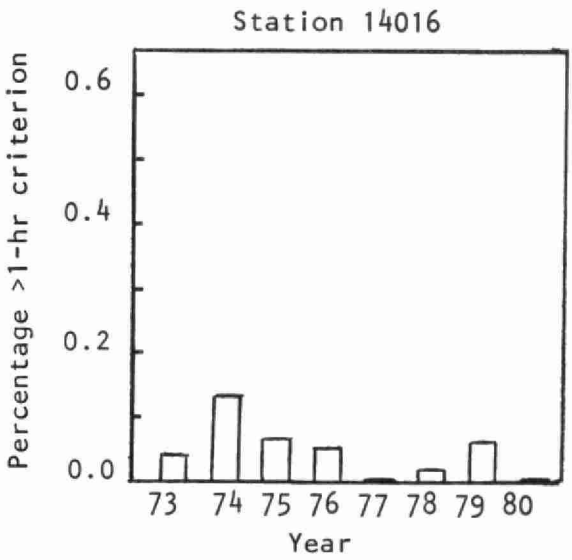
Note (1): Average for 4 months, not representative of annual average.

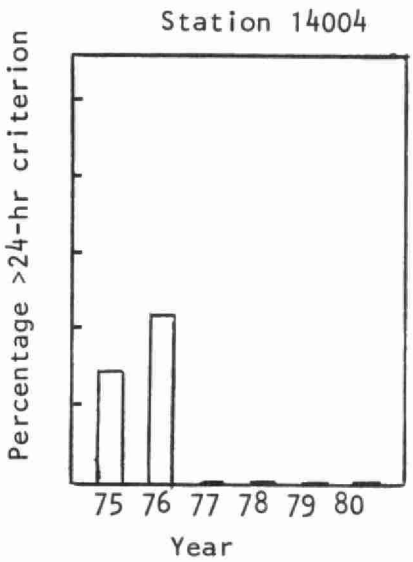
Figure 5. Trend in frequencies of excursions above 1-hour and 24-hour criteria for sulphur dioxide.

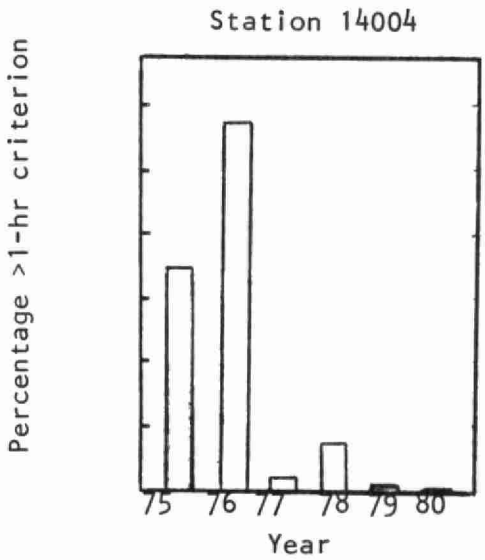












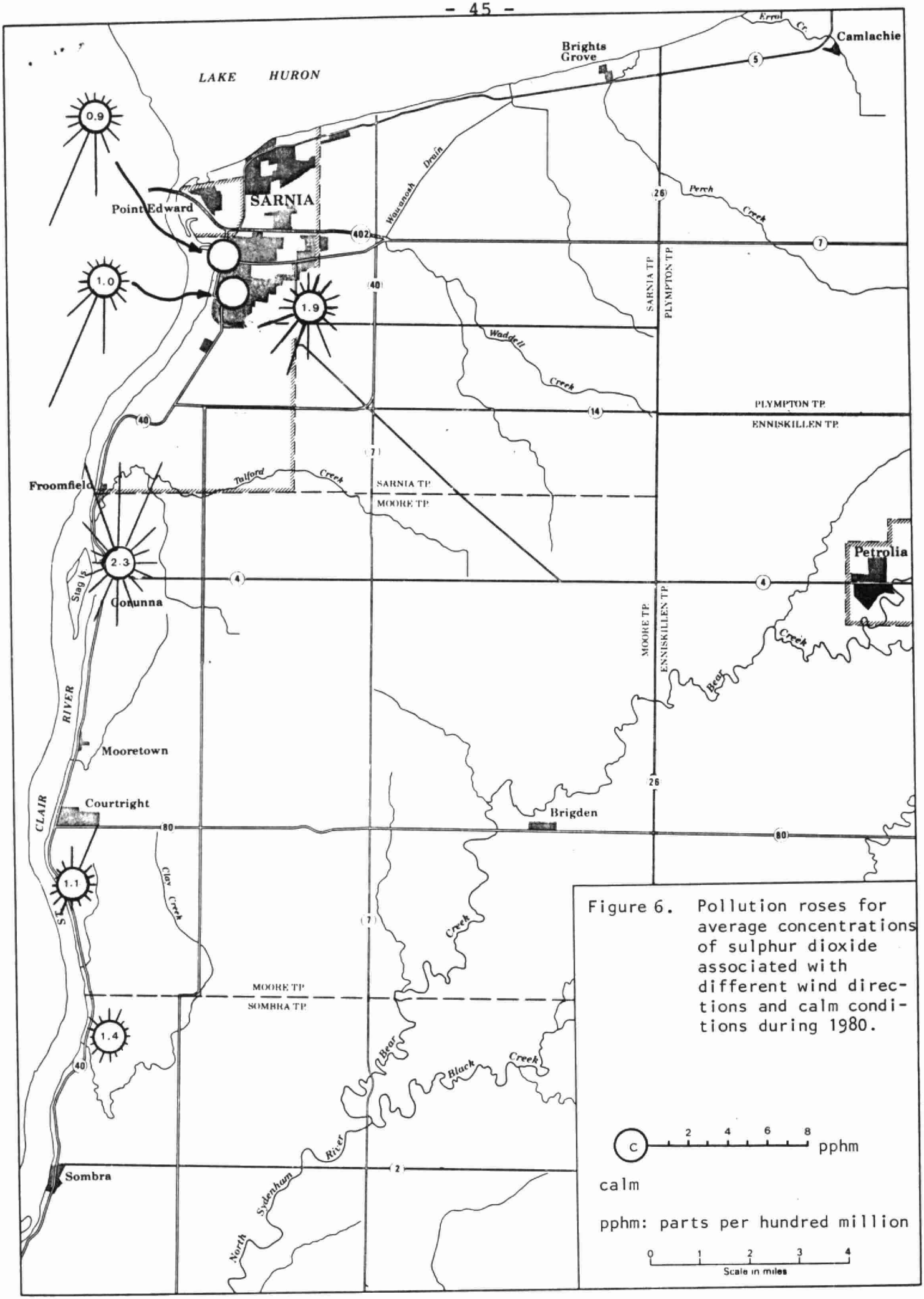


Figure 6. Pollution roses for average concentrations of sulphur dioxide associated with different wind directions and calm conditions during 1980.

APPENDIX 5

HYDROGEN SULPHIDE AND MERCAPTANS, CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS AND OZONE

Table 8. Summary of data for hydrogen sulphide and mercaptans, carbon monoxide, oxides of nitrogen and hydrocarbons.

Pollutant and Criteria	Station number	Year						
		1980	1979	1978	1977	1976	1975	1974
Hydrogen sulphide and mercaptans								
Annual average (ppm)	14062	0.000	0.001	0.001				
	14049			0.001	0.001	0.001	0.001	0.007
Percentage of values above 1-hr criterion[a]	14062	0.00	0.01	0.00				
	14049			0.15	0.01	0.04	0.38	9.78
Carbon Monoxide								
Annual average (ppm)	14064	0	0	0				
	14049			1	2	1	1	1
Percentage of values above: 1-hr criterion	14064	0	0	0				
	14049			0	0	0	0	0
8-hr criterion	14064	0	0	0				
	14049			0	0	0	0	0
Nitric oxide								
Annual average (ppm)	14064	0.01	0.02	0.02				
	14049			0.02	0.02	0.02		
	14902[b]	0.01	0.01					
	14903[b]	0.00						
Nitrogen dioxide								
Annual average (ppm)	14064	0.02	0.02	0.02				
	14049			0.03	0.03	0.03	0.02	
	14902[b]	0.01	0.01					
	14903[b]	0.02						

Table 8. continued

Pollutant and Criteria	Station number	Year						
		1980	1979	1978	1977	1976	1975	1974
Percentage of values above:								
1-hr criterion	14064	0	0	0				
	14049			0	0	0	0	
	14902	0	0					
	14903	0						
24-hr criterion	14064	0	0	0				
	14049			0	0	0	0	
	14902	0	0					
	14903	0						
Total oxides of nitrogen								
Annual average (ppm)	14064	0.03	0.04	0.03				
	14049			0.05	0.05	0.05	0.05	
	14902 (b)	0.02	0.02					
	14903 (b)	0.02						
Total hydrocarbons								
Annual average (ppm)	14064	1.9	2.0	1.7				
	14049			2.6	2.4	2.3	2.6	2.8
	14902 (b)	2.2	2.2					
	14903 (b)	2.3						
Methane								
Annual average (ppm)	14902 (b)	1.7	1.8					
	14903 (b)	1.8						
Non-methane hydrocarbons								
Annual average (ppm)	14902 (b)	0.4	0.3					
	14903 (b)	0.6						

Note: (a) Criterion for hydrogen sulphide
(b) Annual averages based on less than full year of data

Table 9. Summary of data for ozone

Station and Parameter	Year 1980	1979	1978	1977	1976	1975	1974
Station 14049							
Annual average (ppm)			0.023	0.020	0.019	0.024	0.018
Number of values above 1-hr criterion			51	87	56	132	80
Percentage of values above 1-hr criterion			1.1	1.0	0.7	1.9	1.1
Station 14064							
Annual average (ppm)	0.022	0.023	0.018				
Number of values above 1-hr criterion	68	130	56				
Percentage of values above 1-hr criterion	0.8	1.6	1.4				
Station 14118							
Annual average (ppm)	0.022	0.027	0.029	0.027			
Number of values above 1-hr criterion	39	137	249	182			
Percentage of values above 1-hr criterion	0.5	1.7	3.5	2.6			
Station 14902[(a)]							
Annual average (ppm)	0.020						
Number of values above 1-hr criterion	1						
Percentage of values above 1-hr criterion	0.04						
Station 14903[(b)]							
Annual average (ppm)	0.024						
Number of values above 1-hr criterion	81						
Percentage of values above 1-hr criterion	1.5						

(a) Data not representative of full year - instrument operated from January 1 to May 1, 1980.
(b) Data not representative of full year - instrument operated from May 15 to Dec. 31, 1980.

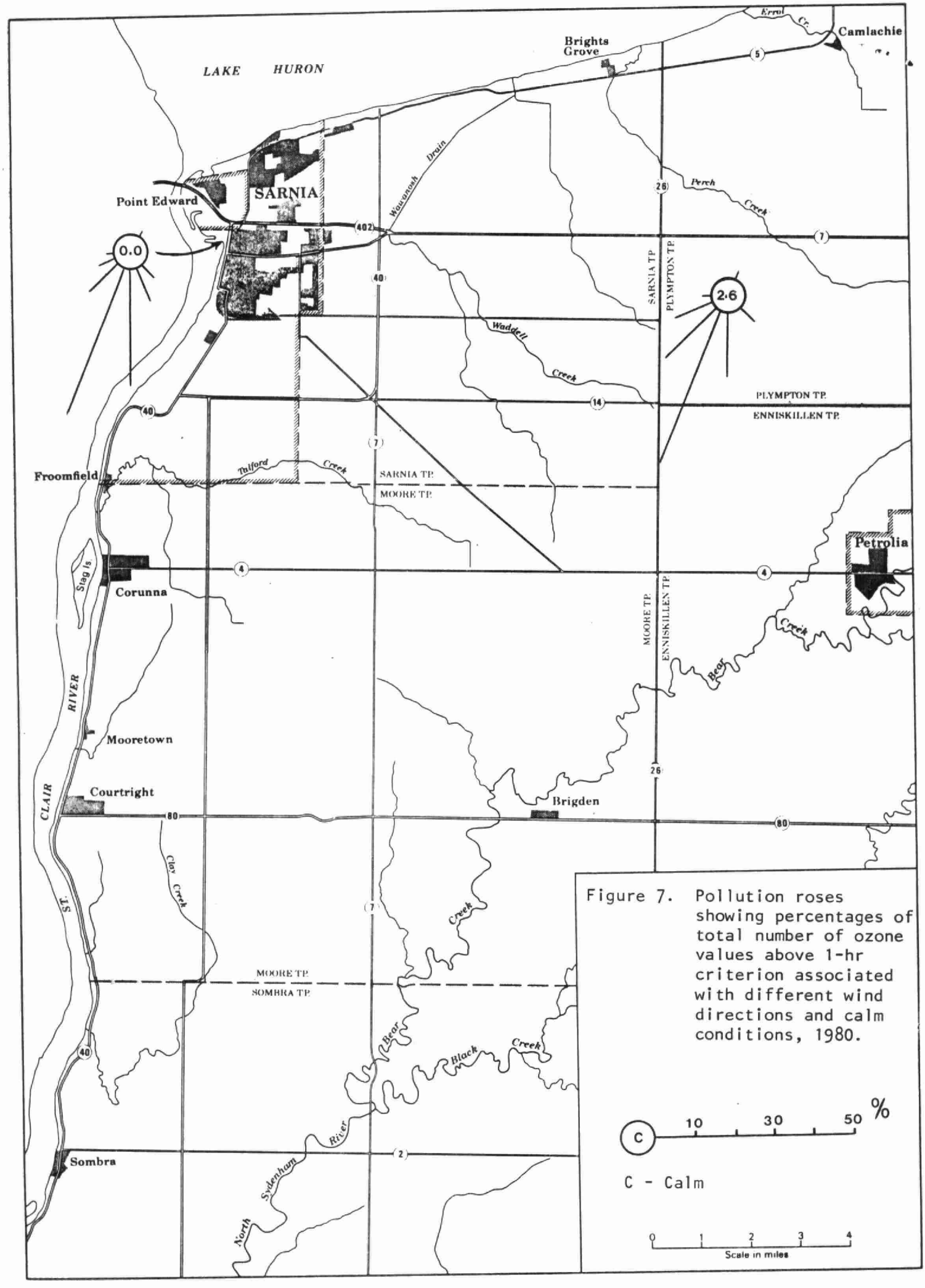


Figure 7. Pollution roses showing percentages of total number of ozone values above 1-hr criterion associated with different wind directions and calm conditions, 1980.

Table 10. Fluoridation rates from 1972 to 1980 (ug F/100 cm²/30 days)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Station 14049													
1972	85	60	22	32	28	56	29	80	20	23	17	45	41
1973	55	50	60	65	65	100	75	60	40	70	55	55	63
1974	67	56	44	66	18		48		50	44	66	80	54
1975	31	39	19	18		29	34	34	22	74	44	31	34
1976	37	53	36	11	18	24	6	42	32	27	29	31	29
1977	55	40	32	16	34	14	43	32	26	46	43	74	38
1978	72	47	38	22	29	39	43	49	45	30	97	55	47
1979	60	60	27	20	34	51	49	43	90	40	41	50	47
1980	2	41	15	33	13	38	19	47		27	59	92	35
Station 14004													
1976						46	38	74	48	39	21	40	44
1977	42	23	53	32	78	31		79	112	29	104	50	58
1978	83	51	53	57	100	65	94	74	74	57	53	59	68
1979	32	63	25	56	54	64	68	129	89	49	32	26	57
1980	16	23	51	62	61	49	83	84		36	28	31	48

NOTE: Underlined values exceeded criteria for desirable ambient air.

APPENDIX 6

FLUORIDES